Practical Notes on Urinary Analysis.

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By William B. Canfield, A.M, M.D.,

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PRACTICAL NOTES

—ON—

URINARY ANALYSIS.

—BY—

WILLIAM B. CANFIELD, A.M, M.D.,

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PREFACE.

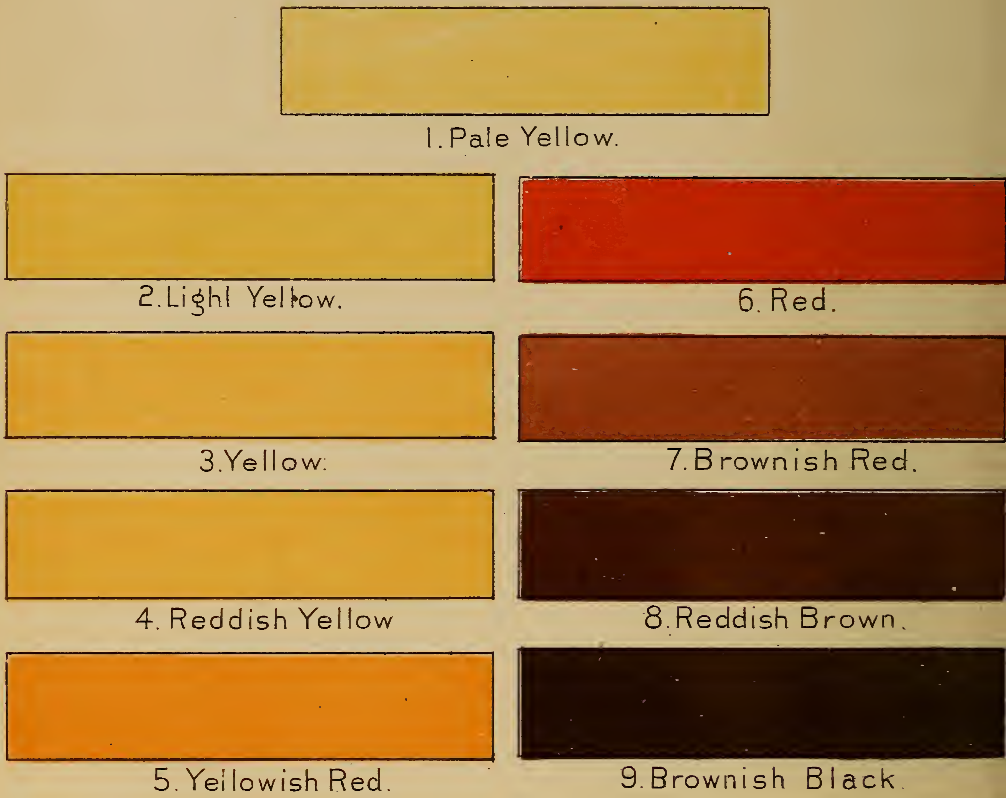
The importance of a knowledge of urinary analysis need not be pointed out here. It is generally admitted that in every case of doubtful diagnosis the urine should be examined. The science, (if it may be so called), of urinary analysis has been, however, carried to such a refinement, that an expert chemist alone is able to master it in all its detail. The busy practitioner has no time to search through manuals and make elaborate tests. In the light of many advances made in this department several old tests have shown themselves trustworthy and many new ones have been added.

The object of these notes will be, after reviewing the general character of the urine, to endeavor to show the tried and reliable tests for detecting normal and abnormal substances in the urine, and at the same time to try to point out the little errors that may creep in in such an undertaking, and to guard against certain mistakes by clearly stating the important and carefully avoiding the superfluous. Besides drawing largely from his own experience, the writer has unhesitatingly made use of the literature on the subject.

W. B. C.

1010 North Charles Street, BALTIMORE.

Table of Colors of the Urine.



PRACTICAL NOTES ON URINARY ANALYSIS.

CHAPTER I.

GENERAL CHARACTER OF THE URINE.

I.—QUANTITY.

The amount of urine passed daily by a healthy man is from 40 to 60 fluidounces (1500 to 2000 c. c.), and by a healthy woman 30 to 40 fluidounces (1000 to 1500 c. c.). This, however, is subject to great variations in health depending upon different circumstances, to be stated below, so that any amount under 15 fluidounces (500 c. c.) or over 90 fluidounces (3000 c. c.), may be considered pathological.

In order to measure the exact amount of urine passed in 24 hours, the bladder is emptied at a fixed hour (say 8 A. M.), and all the urine passed up to 8 A. M. the next day collected in one vessel and measured. Although most writers advocate saving one day's urine for testing, it is only in hospital and exceptional private cases that such a procedure is practicable; for aside from the fact that it is not easy to get the patient or attendants to save so much urine, the decomposition and fermentation of that passed in the first part of the 24 hours, especially in warm

weather, would so contaminate the rest, that the results would be vitiated. Hence, in practice (except in certain cases of diabetes, nephritis, etc., where the the amount is extremely large or small), we generally satisfy ourselves with a single specimen from each day, and preferably the urine passed on rising, as that is less apt to be affected by food or drink, and is what has been called the "blood urine." Occasionally it is well to secure specimens of urine passed in the forenoon and afternoon as well as at night. The most urine is passed in the afternoon, and the least at night.

The amount of urine may be temporarily *increased* in health:

a. By drinking large quantities of liquid.

b. By diminished skin activity, as in cold or damp weather.

c. By taking diuretics.

This amount may be *diminished:*

a. By drinking little liquid.

b. By rest.

c. By profuse perspiration.

Pathologically the amount is *increased:*

a. In diabetes mellitus and insipidus.

b. In granular atrophy of the kidney.

c. In pyelitis.

d. By the absorption of dropsical fluids from the body.

e. In convalescence from acute diseases.

Pathologically the amount is *diminished:*

a. In fever.

b. In the acute and chronic forms of parenchymatous nephritis.

c. In cholera or other diarrhœal diseases.

d. In the formation of dropsical fluids.

e. In those heart troubles where the blood-pressure is diminished.

In life-insurance examinations, it is important that the urine be passed in the presence of the medical examiner.

2. COLOR.

Normal urine may vary in color from a pale yellow to a brownish black according to its concentration, depending in part on the action of the skin and the amount of fluid taken.

The color of the urine, which depends on the presence of urobilin and other substances, should be noted at the bedside. It gets darker on standing. A light clear urine (*urina spastica*) would show absence of acute fever, and a possible presence of polyuria; while a dark-colored urine would denote not only a fever, but might signify a variety of affections of the spleen or liver, a hearty meal, active exercise, etc. Reddish or reddish-brown or smoky urine would point to blood, black urine to the presence of the pigment of melanotic cancer (melanuria). Green or brownish-green urine would indicate bile.

To avoid the confusion of describing the color, Vogel's scale of colors is usually referred to. Flint used to paste gummed, colored paper slips on the record to show the color of the urine.

Different drugs have a decided effect on the color of the urine; for example, rhubarb (chrysophanic acid), senna, and santonin, make it intensely yellow, or a greenish or brownish yellow. Further, logwood, strong coffee, turpentine, carbolic acid, tar, creasote, folia uvæ ursi, gallic acid, tannic acid, indican, kairin, and fuchsin, all color the urine. It is not probable that the presence of albumen can be suspected by the color.

3. SMELL.

The smell of normal urine is slightly aromatic. When concentrated it is strong, when ammoniacally decomposed it is stronger and even putrescent. In certain forms of dyspepsia and liver trouble the urine has a pathognomonic odor. Mineral acids interfere with the normal odor; fixed alkalies make it aromatic. Urine containing blood has a slightly putrid odor resembling that of high game. It is affected by certain drugs. Turpentine gives it the odor of violets. The odor of cubebs, copaiba, sandal-wood, castoreum, valerian, is imparted to urine after administration by the mouth. Also, after eating certain vegetables, such as garlic, asparagus, cauliflower, etc., the urine has a peculiar smell. In diabetes mellitus it may have a sweet smell, due to the acetone.

4. TRANSPARENCY AND CONSISTENCY.

Normal urine is always clear when first passed, and shows, on standing, a slight cloudiness (nubecula) more noticeable in the urine of women. Microscopically a few epithelial and other cells are always present, and in the case of females, vaginal epithelium. Pathologically the presence of the earthy phosphates of lime and magnesium, of the urates, pus, mucus, blood, etc., causes cloudy nrine. The bacteria of decomposition also render it turbid. Normally urine is aqueous. Pathologically the presence of mucus or pus (from gonorrhœa, cystitis, etc.) may cause it to be viscid; and also chyle in the urine (chyluria), as observed in the tropics, gives it a turbid and thick appearance. The foam which normally so quickly disappears from urine, may remain in the presence of sugar, albumen, or blood.

It is well to bear in mind that because a specimen of urine is clear and transparent, it is not necessarily normal.

5. REACTION.

The reaction of normal urine is generally acid. The cause of this is not certain although it is very likely due to the presence of the acid phosphate of sodium ($N_aH_2PO_4$) and other salts. The reaction is tested by means of litmus paper. It is slightly acid when first passed, becomes more acid on standing and then becomes alkaline.

Acid urine turns blue litmus paper red and alkaline urine turns red litmus paper blue. Normally the urine may be alkaline immediately after meals. The acidity is greater:

a. In concentrated urine after perspiration.

b. After fasting.

c. After eating much animal food.

d. After exercise.

e. In fever.

f. In rheumatism and gout.

g. After taking benzoin and the mineral acids.

The urine is only faintly acid or even alkaline:

a. Just after meals, from a vegetable diet.

b. When very dilute.

c. After taking certain mineral waters and other alkalies.

d. After repeated vomiting.

Pathologically the urine is alkaline in cystitis and by decomposition after it has left the bladder.

The alkalinity may be due to a fixed (potassium or sodium) or a volatile (ammonia) alkali. In the former case the litmus paper made blue by the alkali remains blue on drying; in the latter case the blue fades away.

The alkalinity from fixed alkalies causes the precipitation of the earthy phosphates rendering the urine a white, turbid color. Ammoniacal alkalescence brings about the formation of triple phosphates. Yellow turmeric paper is turned brown by alkaline urine,

but it has no special advantage over the litmus paper except to test urine which it is desirable to keep alkaline. In typhoid fever the acidity of the urine is in direct ratio to the fever; in rheumatism, with the pain; while in pneumonia, pleurisy, emphysema, etc., the urine is very acid. The urine may be alkaline from fever, nervous affections, anæmia, debility and in affections of the genito-urinary apparatus, brain, spinal cord, etc.

6. SPECIFIC GRAVITY.

In taking the specific gravity of urine the proportion between its watery and solid constituents is measured. Like the color, this depends on the skin action and on the amount of fluid taken, etc. The specific gravity is measured by means of a urinometer, which consists of a glass tube loaded at its lower end with mercury and with a bulb blown in the middle. The stem, the external diameter of which is as regular as possible, is hollow and the scale is marked upon it. A urinometer when immersed in pure distilled water at a temperature of 60° F. should register at 1000. As the ordinary urinometer is not sufficiently accurate, it should be tested carefully once before using. The specific gravity of urine thus measured is normally between 1015 and 1021 for 40 to 50 ounces per day, and pathologically may vary from 1002 to 1040 and even more. These extremes occur at times without any pathological change.

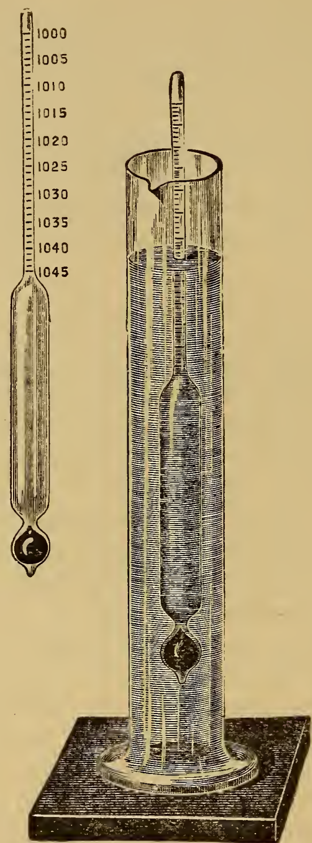


Fig. 1.—Urinometer.

Normally the specific gravity is in inverse proportion to the amount passed in twenty-four hours.

In order to take the specific gravity of a given specimen of urine, a large test tube or cylinder should be about three-fourths filled with urine and after the bubbles have disappeared or have been removed by bibulous paper, and the urine cooled off to the surrounding temperature, the dry urinometer should be gently dipped into the urine and allowed to float without touching the sides of the vessel, and after all motion has ceased the figures may be read off from the stem of the urinometer. In taking the specific gravity, the total amount passed in 24 hours should be known, when possible.

As the ordinary urinometer is too fragile an instrument to be carried safely, in place of it Parke, Davis & Co. of Detroit, Mich., make a set of specific gravity beads, marked respectively 5, 10, 15, 20, 25 and 30, the figures being the last two of the specific gravities, water being 1000.

The beads, arranged in regular succession, the heaviest at the bottom, are contained in a small tube having a hole in the bottom. This constitutes an improved form of urinometer, sufficiently accurate for ordinary clinical observations. To use it, fill the larger tube nearly full of the urine, and plunge slowly into this the tube containing the beads. As the fluid enters the tube, some of the beads will float, while the remainder will remain at the bottom. If

three beads float, we know that the specific gravity of the fluid is between 1015 and 1020.

To ascertain the specific gravity more exactly, add water, drop by drop, to the urine, testing it repeatedly with the urinometer until two only of the beads are floated, the third being in a state of indifferent equilibrium. If two fluidrachms of urine were taken to begin with, and 20 minims of water were required to bring the third bead to the point of sinking, then $120 : 120 + 120 :: 15 : \times$. The value of $\times$ is found to be 17.5, and the specific gravity of the urine is therefore 10175.

Rule.—Multiply the figure on the bead which is made to sink by the total amount of fluid, water and urine, and divide the product by the amount of urine; the quotient will be the figures in (second and) third decimal places of the specific gravity.

The temperature of the urine must be about 60° Fah. (15.6°C.) If higher than this, to obtain an exact result, add to the figure obtained one unit for every 8° F. (4.5°C.) in excess of the standard temperature.

Ordinarily it is sufficient to observe how many of the beads float; the exact specific gravity is of importance only when the whole amount of urine voided during 24 hours is examined; for clinical purposes a rough approximation is all that is generally necessary, and this is all, moreover, that the ordinary urinometer as commonly used affords.

If all the beads float, dilute the urine with an equal body of water, take the specific gravity of the mixture, and multiply the fractional portion of the figure obtained by two.

One great advantage of these specific gravity beads, is that the specific gravity can be taken with as little as two drachms of urine, and we know that it is frequently impossible to get the two or three ounces necessary to float the ordinary urinometer, not to speak of the inconvenience of carrying about several large specimens of urine.

The specific gravity is not affected by the presence of albumen, as it is by sugar. If the last two figures of the specific gravity be multiplied by 2 (2.33 to be more accurate), the amount or solids per 1000 is given. Normally, when the amount of urine is temporarily increased in health, the specific gravity is less, and *vice versa*. Pathologically, the specific gravity is high and the amount of urine passed low:

a. In acute febrile diseases.

b. In some forms of heart trouble.

In diabetes mellitus the specific gravity is generally high and the amount passed abundant and clear. Exceptionally, cases of diabetes mellitus have been reported with abundant urine and low specific gravity. Generally a low specific gravity with abundant secretion of urine is observed in many constitutional afebrile diseases, such as

a. Chlorosis.

b. Hysteria.

c. Contracted kidney.

d. Diabetes insipidus.

It is hardly safe to accept a candidate for life insurance if the specific gravity be below 1010.

The morning urine has a greater specific gravity than that passed later in the day. If the specific gravity be very high, the urine may be diluted with one-half the volume of water and the addition allowed for. For the connection between the specific gravity and the amount of urea present, the reader is referred to another section.

CHAPTER II.

NORMAL CONSTITUENTS OF THE URINE.

A. ORGANIC.—I. UREA.

Urea forms the most important product of decomposition of the albuminous bodies, and the amount excreted is dependent upon the amount of albumen in the food. Adults produce about 20 to 40 grammes (300 to 600 grains) of urea a day and children proportionately more. Urea is eliminated as a nitrogenous compound.

As about one-half of the solid constituents of the urine consist of urea, we may most readily determine approximate variations in the amount of the latter by means of the specific gravity. There are many tests quantitative and qualitative for the detection of the presence of urea in human urine, but the most convenient is the microscopic test. A drop of urine is put on a glass slide and a drop of nitric acid added, and the whole gently heated over the lamp and allowed to cool. The hexagonal and quadrilateral plates of the nitrate of urea, both single and in strata, will be formed. They overlap each other like shingles on a roof. In doubtful diagnosis between a hydronephrosis and an ovarian cyst, the presence of the crystals of the nitrate of urea in the former case, and their absence in the fluid of an ovarian cyst, would

be almost decisive. If the urine be free from sugar and albumen, and contain the normal amount of the chlorides, and its specific gravity be 1020–1024, then it should contain normally 2 to 2.5 per cent. of urea. If the specific gravity be 1014 then 1 per cent. of urea. If the specific gravity be 1030 then 3 per cent. of urea.

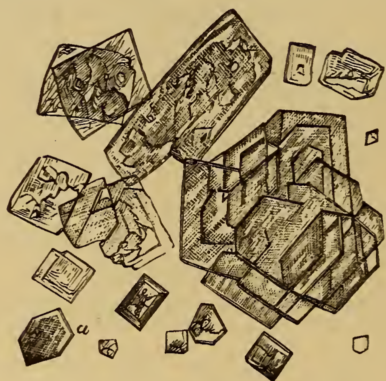


FIG. 2.—Crystals of Nitrate of Urea.

As it is by far the most abundant solid constituent of the urine, the specific gravity of the urine may become a means of estimating approximately the amount of urea present, under the conditions named.

The amount of urea is *increased*,

a. In an exclusively animal diet.

b. In an increased breaking up of the body albumen; as in diabetes mellitus, in fevers before the crisis, in posphorus poisoning, in dyspnœa.

The amount of urea is *diminished*,

a. In a non-nitrogenous diet and in inanition.

b. In uræmia.

d. In acute yellow atrophy of the liver.

d. In chronic diseases.

There are many methods of estimating the amount of urea in the urine, and their principle depends on a decomposition of the urine by means of chlorinated soda, into nitrogen and carbon dioxide, and measuring either the volume of the gas evolved or the specific gravity lost by the decomposition. As it is often important to know the amount of urea present, particularly in gout and rheumatism, and in the pre-albuminuric stage of chronic nephritis, various means have been suggested to measure the urea. All are complicated. Probably Lyon's apparatus, as made by Parke, Davis & Co., of Detroit, affords the most simple means of estimating the amount of urea present in a given specimen of urine.

The amount of urea excreted by a patient in a given time furnishes the physician information of the greatest importance as bearing upon diagnosis, prognosis, and treatment. It is in general an index of the manner in which the various physiological functions of the organism are performed, and, in particular, in certain kidney diseases, it enables the physician to foresee and guard against danger.

Medical men have, however, been deterred from attempting estimations of urea from the expensive-

ness of the apparatus required, and still more from want of confidence in their ability to make any intelligent use of the apparatus if they were to purchase it. This new ureometer is an apparatus which does not require the skillful manipulations of a chemist to obtain with it results which for practical purposes may be considered exact.

No new principle is involved in this ureometer. The urea is decomposed as usual by the action of an alkaline solution of chlorine or bromine, and determined by the volume of gas (nitrogen) generated in the reaction. The original features in the apparatus are (a) the form of the receiver in which the gas is collected and measured, and (b) the graduation of this receiver in such a way that the results are read off directly in percentages of urea.

The apparatus, as illustrated in the cut, consists of:

1. A bottle, provided with perforated rubber cork and delivery tube; in this the decomposition of the urea is affected.

2. A small test tube to contain the urine, graduated to hold 4 c. c., the quantity employed in each experiment.

3. A graduated jar for measuring the gas evolved. This jar is provided at the bottom with an "overflow" tube, and at the top with a vent tube closed with a rubber cap, to secure accurate adjustment of the level of the fluid in the jar at the commencement of the experiment.

The process is as follows: Put into the bottle 20 c. c. of a solution of sodium hypobromite (formula given below); fill the test tube exactly to the mark (4 c. c.) with the urine to be examined, and lower it into the bottle by means of a thread, or by the aid of a pair of dressing-forceps, taking care that none of its contents are spilled in the operation. Fill the graduated jar with water (which must be of the same temperature as the air of the room) to a point a little

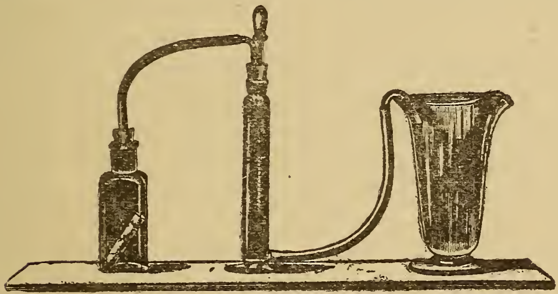


FIG. 3.—Lyon's Ureometer.

above the 0° of the scale, supporting the extremity of the overflow tube so that no water can escape. Remove the rubber cap from the vent-tube, and connect the apparatus, pressing in the rubber corks firmly so as to make the joints air-tight. Finally put on the rubber cap, drawing it down so as to force a little water out of the overflow tube, and bring the level of the water remaining exactly to the 0° mark, the ori-

fice of the overflow tube being on the same level. A little practice will make this easy.

To make sure that the connections are all perfectly air-tight, lower the end of the overflow tube a few inches; a few drops of water will escape from diminished pressure, but if the joints are perfect there will be no further dropping. If there is any leakage the defective joint must be found and the difficulty corrected before proceeding further with the experiment. Having made sure that the connections are perfect, catch the curved end of the overflow tube over the edge of a measuring graduate, as shown in the illustration (an ordinary bottle or any other receiver may be used in place of the graduate). Now, by canting the bottle, cause the urine to flow out of the test tube and mix with the hypobromite solution. Effervescence is at once produced, and the gas evolved forces a corresponding volume of water out of the overflow tube. Shake the bottle occasionally to promote the escape of the gas. When the action appears to be at an end, pour into the measuring graduate water enough to reach above the opening of the overflow tube, in order that cooling of the gas evolved, which is at first quite warm, may not draw air into the apparatus. Let the apparatus stand fifteen or twenty minutes to cool, then shake the bottle containing the urine once more, and proceed to read off the result. To do this, it is necessary to bring the opening at the end of the overflow tube just to the

same level as that of the fluid remaining in the graduated cylinder, since raising or lowering the tube slightly affects the volume of the gas to be measured. The percentage of urea is read off without need of any calculation from the scale of the instrument. An accompanying table will enable the physician to ascertain from the percentage amount of urea in the specimen examined, what is the absolute amount of that compound excreted during the day, provided, of course, the whole of the urine passed during the twenty-four hours has been collected together and carefully measured.

For exact estimations, the temperature of the room in which the experiment is made must be about 70° F. (21° C.). A variation from this temperature of 20° will, however, make a difference in the result of only about 0.1 per cent., so that the temperature correction may be regarded as unimportant.

The solution of sodium hypobromite is made by dissolving 10 parts of caustic soda in 45 parts of water, allowing this solution to stand until impurities have subsided, and pouring off for use the clear portion, which must be kept in well-stopped bottles. When an estimation is to be made, mix with 20 c. c. (5 fluidrachms) of this solution of soda, 1 c. c. (15 minims) of bromine, and allow the mixture to cool to the temperature of the air.

In place of the hypobromite solution prepared in this manner, the physician will find it convenient to

TABLES TO FACILITATE CALCULATIONS IN THE USE OF THE UREOMETER.

Table I.

Per cent. of urea by ureometer.	Quantity of urea in grains in 1 fluidounce.
0.1	.456
0.2	.911
0.3	1.367
0.4	1.823
0.5	2 279
0.6	2.734
0.7	3.190
0.8	3.646
0.9	4.101
1.0	4 557
1.1	5.013
1.2	5.468
1.3	5.924
1.4	6.380
1.5	6.836
1.6	7.291
1.7	7.747
1.8	8.203
1.9	8.658
2.0	9.114
2.1	9.570
2.2	10.025
2.3	10.481
2.4	10.937
2 5	11 393
2.6	11.848
2.7	12.304
2 8	12.760
2.9	13.215
3.0	13 671
3 1	14.127
3.2	14.582
3.3	15.038
3.4	15.494
3.5	16.950

To ascertain the quantity of urea excreted by a patient in 24 hours, collect the whole of the urine for the 24 hours, mix and measure it; then estimate with the ureometer the percentage of urea it contain. Take out from Table I. the quantity of urea per fluidounce corresponding to this percentage, and multiply this by the number of fluidounces of urine excreted.

Example.—The patient has passed 24 fluidounces of urine, found to contain 2.4 per cent. of urea. The total urea excreted will therefore be 10.937 (from the table) X 24=262 488 grains. The quantity of urea normally excreted varies greatly with the diet, averaging about three grains per pound of body-weight in healthy adults on a mixed diet.

By Table II. an approximate figure can be readily found.

TABLE II.

Per cent. by ureometer.	10 fl. oz. urine contain grains urea.	15 fl. oz. urine contain grains urea.	20 fl. oz. urine contain grains urea.	25 fl. oz. urine contain grains urea.	30 fl. oz. urine contain grains urea.	35 fl. oz. urine contain grains urea.	40 fl. oz. urine contain grains urea.	45 fl. oz. urine contain grains urea.	50 fl. oz. urine contain grains urea.	55 fl. oz. urine contain grains urea.	60 fl. oz. urine contain grains urea.
¼	11.4	17.1	22.8	28.5	34.2	39.9	45.6	51.3	57.	63.	68.
½	22.8	34.2	45.6	57.0	68.4	79 7	91 1	102.5	114.	125.	137.
¾	34.2	51.3	68.4	85.4	102.5	119.6	136.7	153.8	171.	188.	205.
12	45.6	68.4	91.1	113.9	136.7	159.5	182.3	205.1	228.	251.	273.
1¼	57.0	85.4	113.9	142.4	170.9	199.4	227.9	256.3	285.	313.	342.
1½	68.4	102.5	136.7	170.9	205.1	239.2	273.4	307.6	342.	376.	410.
1¾	79.7	119.6	159.5	199.4	239.2	279.1	319.0	358.9	399.	439.	478.
2	91.1	136.7	182.3	227.9	273.4	319.0	364.6	410.1	456.	501.	547.
2¼	102.5	153.8	205.1	256.3	307.6	358.9	410.1	461.4	513.	564.	615.
2¾	113.9	170.9	227.9	284.8	341.8	398.7	455.7	512.7	570.	627.	684.
2¾	125.3	188.0	250.6	313.3	376.0	438.6	501.3	563.9	627.	689.	752.
3	136.7	205.1	273.4	341.8	410.1	478.5	546.8	615 2	684.	752.	820.
3¼	148.1	222.2	296.2	370.3	444.3	518.4	592.4	666.5	741.	815.	889.
3½	159.5	239.2	319.0	398.7	478.5	558.1	638.0	717.7	797.	877.	957.

EXAMPLE —Patient has passed 42 fl. oz. of urine, shown by ureometer to contain 2.6 per cent. urea. By the table we find that 45 fl. oz. containing 2½ per cent. urea would contain 512.7 grains urea, and this figure is near enough to the truth for all practical purposes for the physician. By Table I. the exact figure is found to be 497.6 grains.

use the U. S. P. solution of chlorinated soda, which can be kept for a considerable length of time, and can be obtained, freshly prepared, from time to time, of any competent druggist. Keep also on hand a solution of potassium bromide, 90 grains to the fluidounce. Of this solution place in the ureometer 5 c.c. (75 minims), then 25 c.c. (14 fluidrachms) of the solution of chlorinated soda. The mixture gives more uniform and trustworthy results than those obtained with the chlorinated soda alone, which is recommended by Dr. Squibb. It is in fact identical in its action with the hypobromite solution, without the great inconvenience of handling bromine. A few minutes must be allowed to elapse after the mixture is made before mixing the urine with it, but this need occasion no delay, since the mixture can be put into the bottle before filling the cylinder and making the connections.

The activity of the solution of chlorinated soda can be easily tested by adding to a little of it in a test tube a few drops of the solution of potassium bromide, and then a little muriate of ammonia, which should cause brisk effervescence. If this is not the case, it is too much deteriorated for use.

In some rare instances it will happen that the urine contains a larger proportion of urea than the ureometer is capable of indicating. When this is the case, and in general when the specific gravity of the urine exceeds 1030 sugar being absent, it will be best to dilute the urine with an equal volume of water be-

fore making the test. Four c.c. of the diluted urine will then be used as usual in the experiment, but the percentage given by the reading of the instrument must be multiplied by two.

It will be found in practice that an estimation of urea by this apparatus consumes very little time, and results for all practical purposes are as accurate as could be wished.

2. URIC ACID.

Uric acid is in the urine almost always combined with potassium, ammonia, calcium, magnesium, sodium, in the form of the urates.

These being bibasic salts, we have the neutral and the acid salts. The neutral urates are soluble in water and rarely met with when the acid urates are precipitated and crystallized. Uric acid and the urates appear in the form of rhombic plates, whetstones, barrel, envelop, spear, fan, comb, dumb-bell, etc. They are generally colored reddish. Sodium and potassium urate or brick dust sediment is easily soluble in warm water and with difficulty soluble in the cold. It disappears on heating; it adheres to the pot or glass and is more often seen in cold weather, in concentrated urine and when the urine is strongly acid.

Uric acid and the urates are *increased*.

a. In rich animal food with little exercise.

b. In fevers.

c. In leucæmia with enlarged spleen and in pernicious anæmia.

d. In the so-called uric acid diathesis.

e. In all diseases of the heart and lungs and in fact in all conditions (abdominal tumors, liver trouble, etc.) where the function of the diaphragm is interfered with.

Uric acid and the urates are *diminished.*

a. In chronic diseases.

b. During an attack of gout.

The microscopical tests are the most convenient, but require skill. When the red granulated crystals on the bottom and side of the vessel disappear on heating and appear in the cold and disappear on adding caustic potash or soda solution we may presume they are the urates.

Uric acid may be detected by the *murexid test* by mixing a small portion of the sediment supposed to be uric acid with a few drops of nitric acid and then evaporating on a porcelain or platinum plate over a moderate heat to dryness. If uric acid be present, the addition of a drop of ammonia water will cause a beautiful purple-red color of murexid to appear.

By pouring nitric acid upon urine highly charged with urates, a ring much like the ring of albumen in Heller's test, is seen. It disappears on standing or heating, which albumen does not do. The urates show themselves by high temperature, strong concentration and marked acidity of urine

3. OXALIC ACID.

The presence of the oxalate of lime crystals as envelop-shaped and dumb-bell crystals is scarcely of practical importance. They are present in large numbers in so-called oxaluria, and in some calculi. As a slight diminution in the acid phosphate of sodium in the urine causes a precipitate of oxalate of lime crystals their presencc can be of little diagnostic importance.

The ingestion of rhubarb often causes the oxalate of lime crystals to appear in the urine. They are seen as dumb-bell crystals, and may be the principal ingredient of the mulberry calculi. They are present principally in imperfect oxidation or retarded metabolism, and are found in mal-assimilation as in dyspepsia.

4. INDICAN.

A positive or negative result in testing for this substance is of equal value in a urinary examination. It was found that a certain substance, indol, was absorbed during digestion and converted in the blood into indican, but during normal intestinal digestion very little indol was produced while in faulty digestion and allied troubles more was produced and appeared in the urine. Thus indican is *increased:*

a. In all obstructive diseases of the bowel.

b. In pyelitis.

c. In diseases of the spinal cord and nervous system.

d. In urina spastica.

e. After eating.

f. After cholera.

g. In cancer of the liver.

h. In malignant tumors.

i. In Addison's disease.

j. In cancer of the stomach.

k. In acute peritonitis.

Indican is present in increased amount particularly in typhoid fever and in cancer of the liver and stomach.

The most convenient test is by Jaffé. Equal quantities of clear urine and concentrated pure hydrochloric acid are mixed in a test tube, and then a perfectly fresh concentrated solution of the calcic hyphophosphite is added drop by drop until a blue color is observed. If desired, afterward about a drachm of chloroform may be added and the whole shaken, by which the chloroform takes up the color and shows its intensity.

B. INORGANIC CONSTITUENTS OF THE URINE.—

I. CHLORIDES.

The chlorides are present in the healthy urine principally as the chloride of sodium with traces of the chlorides of potassium, ammonia, and calcium.

The amount varies normally according to the amount of common salt taken with the food. The most convenient test for detecting the presence of the chlorides, is the chemical test with the nitrate of silver. If to a given specimen of urine a few drops of nitric acid are first added to keep the phosphates in solution, and then a solution of the nitrate of silver be added, a white, and in healthy urine, thick flocculent cloud of the insoluble chloride of silver will be precipitated, thus proving the presence of the chloride of sodium in the urine thus: $Na\,[Cl+Ag]\,NO_3 = Na\,NO_3 + Ag\,Cl$.

The absence of the chlorides in urine is regarded as a very grave symptom, and in watching a case of the acute febrile diseases, particularly of pneumonia, it is important to test the urine daily or more often with a nitrate of silver solution, and as the crisis approaches the chlorides will be seen to diminish, and may even disappear for a few hours; and after the crisis they begin to reappear. By taking the same amount of urine daily and a silver nitrate solution of known strength, the disease can be watched carefully from day to day.

The chlorides are *increased*,

a. When much salt is ingested.

b. After active bodily or mental exercise.

c. During a malarial chill.

d. In diabetes insipidus.

e. When dropsies are removed by diuresis.

The chlorides are *diminished*,

a. In rest.

b. In all acute febrile diseases (exactly the reverse of urea) *e. g.* in pneumonia when they may be entirely absent at the crisis, a grave omen.

c. In some chronic diseases.

d. In renal diseases with albuminuria and anasarca.

2. PHOSPHATES.

The phosphates consist of the alkaline and the earthy phosphates. The former consist of combinations of phosphoric acid with the bases sodium, potassium, etc., are insoluble in water and are not precipitated by alkalies, and need not be further considered. The latter earthy phosphates consist of combinations of phosphoric acid with calcium, magnesium, etc., and are shown to be present in urine by adding any alkali which causes a white precipitate, which precipitate, however, is colored by blood, bile, vegetable coloring matter or any other such pathological constituent of the urine. The phosphates are increased in the urine in all diseases of the bones such as rachitis, osteomalacia. There is, however, not necessarily an excess of phosphates in the urine simply because they are precipitated, as the alkalinity of the urine or an application of heat as in testing for albumen may cause them to appear.

The triple phosphates when formed in the bladder may give rise to concretions. The phos-

phates may be precipitated by heat alone, and in this case may be mistaken for albumen. The addition of acid will decide. A knowledge of the amount of phosphates present in the urine is of no diagnostic importance, their condition is the important point. When the phosphates are persistently thrown down, there is reason to fear the formation of a stone. When the purulent urine of cystitis undergoes bacterial fermentation, the alkalinity causes the precipitation of the earthy phosphates.

CHAPTER III.

ABNORMAL CONSTITUENTS OF THE URINE.

I. ALBUMEN.

Albumen is the most important abnormal constituent of the urine. Without going into the theory of urinary secretion and excretion it may be sufficient to state that the most generally accepted view of albuminuria is that of Heidenhain which is founded upon the supposition that whenever the continuous epithelial layer on the outside of the convoluted vessels in the glomeruli is in a pathological condition the albumen escapes in the urine. In general, albumen is present in form of serum-albumin, but practically it makes no difference in what form it appears.

It is not easy or practicable to distinguish between serum-albumin and serum-globulin.

Physiologically albumen may be found in the urine of:

a. Infants before the urinary secretion has fairly begun.

b. Weak and delicate children at the age of puberty.

c. Adults after exertion, etc.

Pathologically it may occur from numberless causes, but its presence is always to be considered as of grave importance. It is hardly possible to state

every cause that may give rise to albuminuria. Aside from the so-called accidental albuminuria, in which the albumen does not come from the kidneys, but from the ureters, bladder or urethra we have renal or true albuminuria:

a. In the febrile and infectious diseases.

b. In diseases of the heart and lungs.

c. In actual disease of the kidney.

The tests for the detection of albumen in the urine are various and often complicated. There are at least ten proteids or bodies which may be precipitated by the albumen tests, but practically it is not necessary to make the fine distinction of separating these bodies. When testing a specimen of urine for another physician it is well to know something of the patient's condition.

The following tests are the simplest and most easy of execution and reliable. In all tests the urine should be clear, and if not clear, filtered.

If the urine is too old to be cleared by filtering, add acetic acid and lime water, shake the urine with some magnesia, or add a few drops of a magnesia sulphate solution and the carbonate of sodium and shake. This precipitates the filtrate without affecting the test.

HEAT AND NITRIC ACID TEST.

A test tube is filled two-thirds full with the urine, and then a few drops of diluted acetic acid added to hold the phosphates in solution. The tube

should be held obliquely over the flame, and the upper layer heated to the boiling point. If a cloudiness appear which ten to twenty drops of strong nitric acid do not dissolve, but increase, then albumen is present. In case a slight amount of albumen only be present, the precipitate does not appear for a few minutes. This test may be carried out by first heating the urine, and if the precipitate which occurs be redissolved by strong nitric acid no albumen is present, but if the urine remains cloudy after the addition of the acid, then albumen is present. As an excess of strong nitric acid redissolves a small amount of albumen, the acid should be added drop by drop, and not more than twenty drops to the amount of urine stated. Be careful not to add too much acid. The test tube should be held against the coat-sleeve or a dark background, and allowed to stand for five minutes before a decision is made.

The nitric acid test is a very delicate one, and the heat and nitric acid tests are the accepted ones by the best American life insurance companies. In examining the urine for life insurance it is more common to find disease in its incipiency if found at all, hence great care should be taken in using any tests.

HELLER'S TEST.

This is by far the most reliable and convenient test offered. About two inches of clear urine are poured into a test tube, which is held obliquely while

strong nitric acid is poured down the side of the glass and allowed to flow below the urine without being mixed with it; or the acid may be poured in first, and the urine carefully poured down the side of the tube by rotating the pipette. In using Heller's test, to bring the urine and acid in contact, draw up the urine

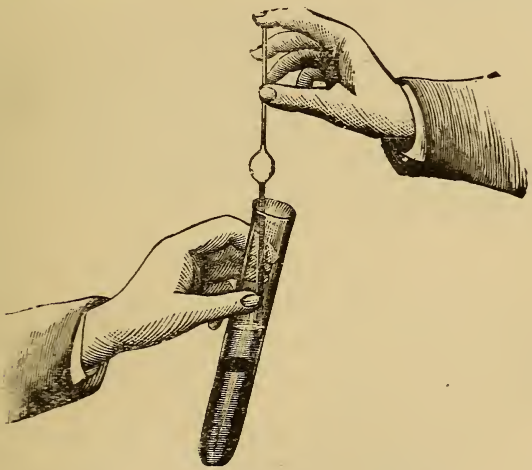


FIG. 4.—Nitric Acid Test for Albumen.

in a pipette, and then rotate the pipette so as to let the urine out as slowly as possible. At the junction of the two fluids the slightess trace of albumen will cause a cloudy ring of albumen. Instead of a test tube, a conical glass may be used. Of course the result will be the same if the urine be carefully poured

upon the acid, or if the latter be passed through the urine by means of a pipette. A well defined ring-shaped cloudiness may also be caused by urea and uric acid (in which case it is higher up), or by certain resinous substances as in cubebs, copaiba, turpentine, etc. (in which case the cloudiness is at once redissolved by alcohol).

PICRIC ACID TEST.

A few drops of a saturated watery solution of picric acid are added to clear urine, and if albumen be added a slight cloudiness will show itself at once. Any cloudiness which may appear later need not necessarily be due to albumen.

TRICHLORACETIC ACID.

Raabe's trichloracetic test has been recently highly praised for its delicacy by Dr. D. Meredith Reese of the Johns Hopkins Hospital, but Penzold says it is not reliable.

In an emergency boiling the urine with vinegar and concentrated salt solution is worth mentioning as a test.

Great care is necessary in carrying out all these tests and in many cases it is only after testing urine from a patient at several different times that a decision can be reached. In carrying out the first test the phosphates should not be taken for albumen merely because they are precipitated by heat. Again the

presence of a small amount of albumen may be redissolved if too much nitric acid be added. In using the heat test on albuminous urine which contains a cloudy precipitate of the acid urates, a very striking contrast may be observed by slightly warming the middle part of the urine until the urates here are redissolved and heating the upper layer to a boiling point until not only the urates have been redissolved, but the albumen has been precipitated; then the urine in the test tube will be clear in the middle while the lower layer will contain a precipitate of the acid urates and the upper part a precipitate of albumen. It is advisable to test urine as soon as possible after the specimen has been passed, for at all seasons, but especially in warm weather, the urine becomes decomposed and alkaline and large amounts of the carbonates (of ammonia) and uncombined carbonic acid gas are present. This also the case when the patient has been drinking certain alkaline mineral waters. When such urine is examined for albumen and nitric acid is added a lively effervescence takes place and carbonic acid gas is set free. It is often difficult to decide whether such urine contains albumen or not, for if the albumen be present in a small quantity it is liable to be redissolved by the large amount of acid necessarily aded until the all effervescence ceases. It is sometimes desirable to compare the amount of albumen in the urine of the same patient from day to day. The process of precipitating the albumen filtering and

weighing the filtrate (the weight of the filter paper being known) is too time-wasting for a busy man. Approximately the amount per cent. may be estimated by taking test tubes of equal size, filling them daily to the same point (two-thirds full) and adding the same amount of nitric acid (about twenty drops) and letting the tube stand a few minutes.

There is great carelessness and uncertainty of expression in noting the percentage of albumen present. Some writers speak of 25 and 50 per cent. This is by bulk. In reality 3 per cent. of albumen is rarely found and ½ per cent. is a large amount.

In general we may say that when the amount of albumen is 2 per cent. to 3 per cent., the whole fluid is completely coagulated. When there is 1 per cent. of albumen present, the coagulum in the test tube reaches half-way up to the level of the urine.

When	0.5	per cent.	⅓	the way	up.
"	0.25	"	¼	"	"
"	0.1	"	$\frac{1}{10}$	"	"

" 0.05 " the curved part of the tube is barely filled with albumen, and when there is less than 0.01 per cent. present, there is a slight cloudiness, but no precipitate.

CYCLIC ALBUMINURIA.

A very common form of albuminuria is this so-called "cyclic" or "physiological" albuminuria, which has been the subject of so much discussion on

the part of English and German writers. Although so much has been written on this subject, there seems to be a tone of uncertainty as to what form of albumen this is, and what the result of such conditions is. Clinicians are beginning to look upon such conditions as entirely compatible with health, and yet it is impossible to say that such albuminuria is not the first warning of a serious renal trouble. Even the careful and conservative medical directors of the largest life-insurance corporations keep on hand two sets of opinions—one opinion which appears in medical literature that such conditions are not necessarily dangerous, and such an albuminuria is perfectly compatible with health. The other opinion is expressed when a case of cyclic albuminuria occurs in an applicant for life insurance. Then, if nothing else can be found against the applicant, he is postponed, and if albuminuria still continue for several weeks, there is a very large chance for rejection; indeed, examiners claim to have followed up such rejected cases and to have found that most if not all of them have eventually succumb to some renal disease or kindred trouble. The trouble is that the insurance companies will not take the risk. The pathology of the incipiency of renal disease will have to be understood much better than it is now before such cases can be justly judged.

As the use of acids and corrosives is always attended with inconvenience in the office and more especially at the bedside, Dr. G. Oliver, of Harro-

gate, England, suggested that these tests be put up in the shape of test papers impregnated with the test substance, or as compressed tablets of the test substance. These papers and tablets are prepared by Parke, Davis & Co., of Detroit, who put them up in neat and convenient cases containing either the papers or tablets with directions for use.

Four different reagents for albumen are furnished in this series of test papers.

1. Potassio-mercuric iodide.
2. Sodium tungstate.
3. Potassium ferrocyanide.
4. Picric acid.

These reagents are all used in connection with citric acid. Put into a test tube 30 minims of the urine with a citric acid paper (or if the specimen be alkaline, more than one acid paper) and allow a few moments for the acid to become dissolved. If a cloudiness is produced by the acid, it is due to mucin, or uric acid, or rarely to oleo-resin, as where balsam copaiba has been taken medicinally. The urates dissolve on warming the urine, mucin remains, being distinguished by this behavior from any other constituent of the urine. The oleo-resinous precipitate clears up by boiling, but quickly returns while the urine is yet warm.

After observing the effect of the acid alone, add the albumen precipitant—one of the four named

above. As the reagent dissolves, albumen, if present, is precipitated in the form of a distinct cloud, soon resolving itself into flakes. If any cloudiness is produced, the urine must be heated, when, if the reaction is due to albumen, the precipitate remains undissolved. A precipitate cleared up by heat may consist of peptones, or of compounds of vegetable alkaloids.

It a very large quantity of albumen be present, it may happen that the paper will become coated with the precipitate which forms instantaneously on its surface, and no cloudiness appear in the urine. Such a contingency could very rarely occur, and application of heat would be sure to reveal the presence of the albumen.

Another method of using the papers is thus described by Dr. Oliver: "Those who prefer to develop a zone of precipitation along the plane of contact of a test solution and the urine can do so with these papers as follows: Put the reagent paper with 15 minims of water into one test tube, and a similar quantity of the urine with a citric acid paper into another. When the reagent is dissolved a portion of the solution is taken up with a pipette and allowed to trickle down the side of the tube, in which it will either glide over the urine, or collect below it." Dr. S. C. Smith, of Halifax, suggests as a still better way to bend the papers into a circle so as to fit the inside of the test tube, and push them down, say within an

inch of the bottom of the tube, which is then to be filled with the urine. If albumen be present, the whole of the urine below the papers becomes opaque, while that above them remains transparent and unchanged. The advantage of observing separately the effect of the citric acid is, however, lost in this mode of applying the tests.

POTASSIO-MERCURIC IODIDE.

This is the most sensitive of all the tests for albumen, and in general should be the first test tried, since if this fails albumen is surely absent. The reagent precipitates peptones, and vegetable alkaloids; the precipitate of peptones is cleared up by heat, but returns as the urine cools. The precipitate of alkaloids forms a diffused cloudiness which does not break up into flocculi. On applying heat, it clears up, and it is soluble also in alcohol. In case albumen and alkaloids are present together, the fluid will partially clear on heating.

SODIUM TUNGSTATE.

This reagent will detect one part of albumen in 20,000 of urine; it is therefore nearly as sensitive as the potassio-mercuric iodide. It has the advantage over the latter that it does not precipitate alkaloids. It does however, precipitate peptones, the precipitate redissolving on applying heat.

PICRIC ACID.

This test equals in sensitiveness that just named, and has this advantage that it may be used to detect either sugar or albumen. It precipitates like the potassio-mercuric iodide, peptones and vegetable alkaloids, and also throws down oleo-resins, and occasionally uric acid. The discrimination of the albuminous precipitate is, however, made with certainty by the application of heat which dissipates all other precipitates.

POTASSIUM FERROCYANIDE.

This test is less sensitive than others in the series, but is capable of detecting albumen where present in the proportion of 1 part in 12,000 of fluid. It is therefore comparable in the range of its indications with nitric acid. It does not precipitate peptones or the vegetable alkaloids which one is likely to meet with in the urine. It is therefore not liable to lead to false conclusions in the hands of careless observers, and it is selected on this account by Dr. Oliver and by Dr. Purdy as likely to be of the most service to medical men who have not had much experience in applying chemical tests.

QUANTITATIVE ESTIMATION OF ALBUMEN BY THE METHOD OF DR. OLIVER.

Twenty minims of the urine are placed in the smaller test tube, a mercuric and a citric acid paper introduced into it, and the tube is shaken during one

minute, so that the whole of the albumen is precipitatee. The opacity produced in the fluid is directly proportional to the quantity of albumen present, and this is determined by the aid of the printed test lines which are provided for the purpose. The fine lines are just discernable when the urine contains 1-10 per cent. of albumen. The dark lines are rendered indistinct if there is more than 0.2 per cent. present. If the fine lines are not distinguishable, add water a little at a time, until they can just be discerned through the centre of the tube.

If it require five times the original volume of the urine to reduce the opacity to this extent, the urine contains 5×0.1 per cent., *i. e.*, one-half of one per cent. If the quantity of albumen is greater than this, it is best to dilute a portion of it two, four, or eight times with pure water before precipitating the albumen, and multiply the result obtained by the factor representing the degree of dilution of the urine.

The quantitative test for albumen may be made with Eshbach's albuminometer. It seems hardly worth while to discuss the other proteids found in the urine, such as serum-globulin, globulin, paraglobulin, peptones, etc. Some cases of cyclic or so-called physiological albuminuria may be due to these proteids.

The report of the Albumen Tests Committee from the Clinical Society of London, while not very conclusive, is on the whole quite satisfactory. Of the

eight tests used, they decided that a solution of potassio-mercuric iodide with citric acid, particularly when used after Heller's method, gives the most delicate and clearly marked reaction. The objection to this test is that the citric acid precipitates the urates which may be mistaken for albumen. The nitric acid test used by Heller's method is of great delicacy, and generally sufficiently trustworthy in spite of the fact that the acid is not easily portable. Anyone who may devote himself to the thorough use of one of the tests will be able to decide the presence or absence of albumen in urine, as minutely as all practical need demands. The papers, and particularly the pellets, have the great disadvantage of undergoing change through the absorption of water from the atmosphere — in short, they are hygroscopic. As mentioned above, trichloracetic acid, as used by Boymond, Raabe, and Reese, is very delicate, but concentrated urine must first be diluted, otherwise the urates are precipitated and mistaken for albumen.

2. SUGAR.

Although various kinds of sugars are pathologically present in the urine, such as sugar of milk (lactose) in the urine of lying-in women, also occasionally inosite and levulose, still these are of minor importance and when we speak of sugar in the urine we generally refer to *glycosuria*, meaning the presence of grape sugar (glucose, dextrose) in the urine. Such

urine is much increased in quantity, pale, of high specific gravity, 1030 to 1045.

Von Brücke and Bence Jones claimed against Seegen, George Johnson and others several years ago that a trace of grape sugar was present in all normal human urine, but in such small amount that it escapes the ordinary tests and hence this needs only a mention here. One reason that laboratory tests do not furnish reliable data from which to draw conclusions, is that such tests are usually made not with urine containing sugar but with distilled water to which has been added anhydrous glucose in certain fixed proportions. It may be easily seen that urine containing sugar and innumerable other things which chemists do not yet understand will not react like the above test solution.

Just as the mistake is so often made of saying that a person with albumen in the urine has Bright's disease, so one with sugar in the urine is often said to have diabetes mellitus and hence with the disappearance (practically speaking) of these two abnormal ingredients of the urine, hopeless cases of Bright's disease or diabetes mellitus have been said to be cured.

Pathologically sugar may appear in the urine as a (a) transitory or a (b) permanent condition.

As a transitory condition it is described as

a. Glycosuria.

As a more lasting or permanent condition when associated with other symptoms it is called:

b. *Diabetes mellitus.*

a. Glycosuria may occur after taking certain poisons or drugs and in consequence of disturbances of the digestion or nervous system.

b. If the glycosuria continue it may bring certain other symptoms with it and then we have a *diabetes mellitus.*

The tests for detecting the presence of sugar are so numerous that it is no easy matter to be master of them all. In carrying out these tests, however, it must be remembered that if albumen be present it should first be precipitated and removed by filtration before the sugar test is made.

Before testing for sugar the specific gravity of the urine should be taken. If it is 1030 the presence of sugar should be suspected, if 1035 and over, the suspicion of sugar should be very strong. Further, if the urine be very pale and exceed 50 ounces per day, with high specific gravity, sugar is almost sure to be present. It should not be forgotten, however, that many cases of glycosuria with large quantity of urine and with low specific gravity have been reported.

Although a large number of sugar tests have been suggested and most of them depend on the same principle, it is a sad fact that no test is strictly reliable. Investigators have found again and again unknown substances in the urine that reduce the copper just as sugar does. Indeed, it is no uncommon thing, after cases of arsenic poisoning to find arsenic in the urine

and this substance answers to all the sugar tests with a striking similarity. However, until more reliable tests are offered the following are given as the best.

MOORE'S OR HELLER'S TEST.

This is a favorite test in Germany. A small quantity of urine is heated with one-third of its volume of a concentrated caustic potash solution in a test-tube, and if sugar be present the urine turns a yellow-brown or brown color according to the amount of sugar present. This test is not reliable when the sugar contained is 0.5 per cent. or less. The urine must be boiled for several hours. The presence of rhubarb or senna in the urine may cause a similar reaction. Although not a delicate test, still it is a reliable one if it yield a negative result, and hence it is good as a preliminary test.

COPPER TESTS.

These all depend upon the power which grape sugar possesses of reducing the oxide of copper, and are therefore called reduction tests.

TROMMER'S TEST.

As in the first test, to a quantity of urine one-third its volume of caustic potash or soda solution is added, then a sulphate of copper solution (1:10, or even weaker) is added drop by drop until there is

only a small part left undissolved on shaking the tube. If this mixture be then heated, the presence of sugar will cause, before the boiling point is reached, a yellow-red precipitate of cuprous oxide (Cu_2O). If no sugar be present the fluid will show a greenish hue. If a precipitate does not form at once on heating the tube, the test has no value. Occasionally certain drugs in the urine are capable of reducing the copper, and it is possible that these are in the urine. Many reducing agents which the chemists do not yet understand make this test of doubtful value. If the sulphate of copper solution be boiled first and then added, the test is strengthened, or if the sulphate of copper solution be added in the cold, and the test-tube be set aside for twenty-four hours, the test is more reliable, since sugar is probably the only substance which reduces copper in the cold.

The other copper tests of Fehling and Pavy are both reduction tests and not as convenient as the last. Pavy's pellets are also convenient for bedside tests, but they are apt to change and become unreliable.

FEHLING'S TEST.

Fehling's test is considered sufficiently accurate for all practical purposes, and is recommended by the best American life-insurance companies. Fehling's solution may be prepared in two parts and mixed when wanted, as it does not otherwise keep.

No. 1.—Cupric sulphate, C.P., 34.64 grammes (520 grains).
Water. . . . . q. s. ad 500 c. c. (15 ounces).

No. 2.—Rochelle salt (crystallized). . 173 grammes ($5\frac{1}{2}$ ozs.).
Solution of caustic sodd, sp.
gr. 1.34. . . . . 100 c. c. (3 ounces).
Water, ... q. s. ad 500 c. c. (15 ounces).

For use mix equal parts and use as in Trommer's test. One c. c. (15 drops) of this is exactly reduced by 0.005 gramme ($\frac{1}{13}$ grain) of grape sugar. Dr. Charles W. Purdy has devised a new formula for the detection of glucose, both qualitative and quantitative. It seems to be a good and fairly reliable test, but it is too early yet in the stage of probation to be generally adopted. Its principle is the same as all the copper tests. It is very carefully and satisfactorly prepared by Messrs. Hynson and Westcott, legitimate pharmacists of Baltimore.

BOETTGER'S BISMUTH TEST.

This is a simple and reliable, but not delicate test. The urine is made alkaline by adding equal parts of liq. potassæ or sodæ and then a pinch of subnitrate of bismuth, and boiling for a few minutes. If sugar be present it reduces the bismuth, and the black metal will be deposited on the sides of the test tube.

FERMENTATION TEST.

The fermentation test is very reliable, but not delicate, and entails a long wait. A small piece of ordinary baker's yeast is put into the bottle contain-

ing the suspected urine, and this is immersed neck downward in the same urine. If sugar be present, the evolution of carbonic acid gas by the yeast will be shown by the displacement of the urine.

PHENYLHYDRAZIN TEST.

The phenylhydrazin test is the latest, and probably most sensitive and reliable test for glucose. It was introduced by Emil Fischer in 1883, and since that time has been carefully studied and modified by v. Jaksch, of Graz. Two pinches of the muriate of phenylhydrazin, and four pinches of the acetate of sodium, are put into a test tube with water and heated, then an equal quantity of urine is added, aud the whole is again heated and set aside to cool. If sugar is abundant it falls down in delicate yellow crystals. If only a small amount is present the delicate yellow crystals of phenylglucoazone may be recognized under the microscope. This test is a very satisfactory one, but takes more time in case a small amount of sugar is present. Since its introduction, there have been raised plausible objections to its reliability. Aside from this, any test that requires the careful use of the microscope for the detection of a very delicate crystal, will hardly find general acceptance.

As in the case of albumen, so with sugar, it is best to become thoroughly acquainted with one good test and use it always, but understand the others sufficiently well to resort to them in case of doubt.

Test papers and tablets have also been prepared for the detection of sugar. They have given satisfaction, and are of great convenience when more elaborate means are not at hand. They are put up by Messrs. Parke, Davis & Co., of Detroit.

Two tests are furnished in this series:

1. Indigo carmine.
2. Picric acid.

These reagents are both used in connection with sodium carbonate in the manner described under the individual heads following.

The diagnosis of glycosuria may be made with certainty by means of these test papers, and an approximate estimation made of the quantity of sugar present.

The presence of albumen and of uric acid in the urine does not interfere with either of these tests, which are capable of detecting the smallest quantities of sugar that can be considered pathological.

INDIGO CARMINE.—MULDER'S TEST FOR SUGAR.

This is an exceedingly sensitive test for diabetic sugar, and its indications may be accepted as infallible.

Place in a test tube 30 minims of water with an indigo and a sodium carbonate paper. Heat the tube gently until the indigo is dissolved. [The solution should be of only a pale blue color. A portion of one of the iudigo papers may suffice, but the

whole of the soda paper should be used.] Add to the blue solution from a pipette one drop of the urine to be tested, ond keep the fluid at a boiling point, without, however, permitting active ebullition, for sixty seconds. If no change is produced add a second drop of the urine, and heat once more. If any notable quantity of sugar is present, the fluid will be observed to change from pure blue to violet, then to purple and red, and only a trace of sugar, the color will merely change to one of the intermediate shades.

☞Normal urine itself produces a reaction if added in sufficient quantity, 5 to 8 drops generally being sufficient to change the color to purple or red. If, however, no more than one drop of the urine is employed in the test, a change in color is proof that sugar is present in abnormal quantity.

☞If the tube is agitated during the experiment so that the fluid is brought in contact with the oxygen of the air, the reaction is retarded. Indeed the blue color of the solution may be momentarily restored even in presence of a large excess of sugar by vigorously shaking the tube, and the color can be discharged and restored repeatedly, by the alternate action of the sugar and the oxygen of the air.

QUANTITATIVE ESTIMATION OF SUGAR BY INDIGO CARMINE.

The test papers may be made to yield approximate quantitative results by observing that the color of 30 minims of a pale blue solution of indigo is

changed to yellow by heating one minute with one minim of a urine containing ten grains of sugar to the fluidounce, or by heating two minutes with one minim of a urine containing five grains to the fluidounce. For exact work, it is necessary of course to have papers especially prepared, containing a definite quantity of the reagent, but a rough approximation to the truth may be based upon the statement just made, and information of great value may be thus obtained in observing the influence of remedies in a case of diabetes.

If the quantity of sugar is smaller than that named, the change of color will be only partial, but exact quantitative estimations are of less importance in these cases than where the amount is more considerable.

In case the urine contains more than ten grains of sugar to the fluidounce, it will be necessary to dilute it until it is reduced to that strength. If four times its volume of water is required to effect the change in one minute, the urine must contain $5 \times 10 =$ 50 grains of sugar to the fluidounce. The details of this method can be best worked out by each individual for himself.

PICRIC ACID.—DR. GEO. JOHNSON'S TEST FOR SUGAR.

When an alkaline solution of picric acid is boiled with a little glucose, picramnic acid is formed, and the color of the solution changes to a garnet red. To apply the test to the urine, put in a test tube one

of the picric acid papers with 20 minims of water and about 3 grains of sodium carbonate, add 10 minims of the urine and boil sixty seconds if necessary. The color of the mixture always darkens perceptibly, but if sugar is present the change is much more prompt and decided than in the case of normal urine. If the color changes rapidly to a dark red, repeat the experiment with 5, 3 and one minim successively, to form an approximate estimate of the quantity of sugar present. If one minim gives a strong reaction, dilute fluid gives only a deep amber color with a distinct shade, however, of red. In a diluted urine this reaction will indicate the presence of about one grain of sugar to the fluidounce.

About the same shade of color is generally produced by two minims of a normal urine, so that there should be deducted from the result obtained about half a grain to the fluidounce, as "normal sugar." This test should always be confirmed by the indigo carmine test, since there are other substances than sugar—notably kreatinin—which react like glucose with picric acid.

COMPARATIVE VALUE OF TESTS FOR SUGAR IN THE URINE.

The *copper test* which is commonly employed, is perhaps the least trustworthy for all the tests for glucose. Among the normal constituents of the urine, uric acid is capable of reducing copper compounds,

and numerous substances which may be accidentally present have a similar action. Kreatinin and many other organic compounds prevent or retard the precipitation of small quantities of cuprous oxide, so that urine containing less than one grain of sugar to the fluidounce fails to respond to the copper test, or gives an indication only after half an hour or a longer time.

Picric acid is an exceeeingly sensitive reägent for the detection of sugar, but a larger amount of alkali must be used than can be put in the form of a test paper, so that a supplementary supply of the alkali must be carried in the pocket case, if the test is to be used at the bedside. The reagent is not affected by uric acid, nor by most of the substances occasionally present in the urine which reduce copper. It does react, however, with kreatinin present in normal urine, and with ferrous salts, tannin, and inosite which occasionally occur in the secretion. Normal urine always shows a distinct reaction, as though it contained as much as ½ grain in the fluidounce of glucose.

Indigo is not affected by any known normal constituents of the urine. Since normal urine always produces a reaction with it, we must conclude either that glucose (or inosite) is constantly present in urine in small quantities, or else that there is a constituent constantly present which has a similar action but is yet unknown. Of the possible accidental constituents of the urine, only ferrous salts and tannic acid affect

indigo, so that we may regard this test as not only the most sensitive, practically, of any yet proposed, but as practically free from fallacies. Finally, unlike the copper test, indigo carmine can be preserved unchanged for years, especially in the convenient form of these test papers.

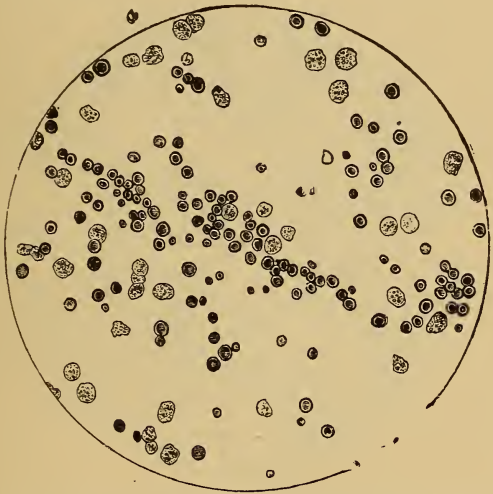


FIG. 6.—Colored and (*a*) Colorless Blood Corpuscles of Various Forms.

3. BLOOD.

Blood occurs in the urine in two different forms.

a. As *Hæmaturia*, when the blood-coloring matter is present in the urine in combination with blood corpuscles, and

b. As *Hæmoglobinuria*, when very few or no blood corpuscles are present and the blood is in solution in the urine.

In *Hæmaturia* the blood may come from the kidneys, pelvis of the kidney, ureters, bladder, urethra

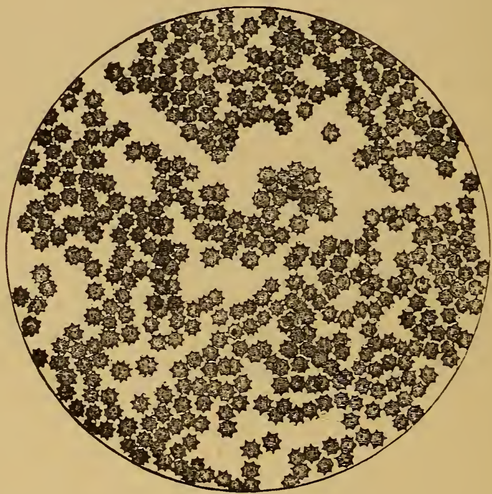


FIG. 7.—Cremated Red Blood Corpuscles in Urine, x350.

or vagina. The presence of blood may be suspected by the brownish-red color of the urine and the reddish sediment which appears on standing. Hæmaturia may be normal in character. Blood from the kidneys is generally well mixed with the urine, making it

smoky; when from the bladder it is usually stringy and clotty, and comes out at the end of micturition.

With a power of 300 diameters the blood corpuscles can be easily recognized either in their usual bi-concave form or, if the urine be concentrated and acid, they appear with crenated edges and much shrunken.

HELLER'S TEST.

This convenient and easy test is made by adding a caustic soda solution to some urine in a test-tube and heating. The precipitated phosphates are colored reddish-brown by the blood-coloring matter and fall in a thick cloud to the bottom of the tube. Testing for *hæmin* cystals is difficult for the inexperienced, but may be necessary at times. If some blood, or sediment supposed to contain blood, be heated to the boiling point with glacial acetic acid and a trace of common salt, and then slowly evaporated, there are found brownish yellow rhombic crystals of hæmin. The preparation should be moistened with a little glycerin and examined with a high power under the microscope. If hæmorrhage occur in the urinary tubules, casts or cylinders made up of blood corpuscles are seen under the microscope.

a. Hæmoglobinuria occurs in some fevers, nervous troubles from burns and after carbolic acid poisoning. So-called paroxysmal or periodic hæmoglobinuria has been lately described as a disease due to sudden effects of cold on the skin and particularly the

feet. It is often connected with syphilis. Albumen is often present from the dissolution of the blood corpuscles. If Heller's test gives a positive result and no blood corpuscles are visible under the microscope, then we may conclude it is hæmoglobinuria.

ALMEN'S TEST.

Add a few drops of a freshly made tincture of guaiac to the suspected urine, and it will turn green. Shake well and add a few drops of old oil of turpentine. The hæmoglobin will change the color of the precipitate to blue. The most convenient and reliable test is to examine this sediment microscopically.

4. PUS.

Purulent urine is cloudy, grayish-yellow, with a heavy sediment which, in alkaline urine, has the appearance of a tough, stringy mucus-like mass. Thus the chemical test for pus is to add a solution of caustic potash to the urine and observe whether the sediment takes on the above described appearance. Much more reliable is the microscopical test which shows at once the presence or absence of the pus corpuscles. On the addition of a drop of acetic acid, the nuclei become distinct and the outline of the corpuscle has a glassy appearance. Urine containing pus in large amount generally contains albumen. It is not easy to find the source of the pus. Pus in the urine may resemble mucus. The latter, however, forms a light

flocculent cloud, which remains suspended in the urine for some time. Microscopically, the threads of mucus and the cells are at once recognized, but as the mucus and pus cells are microscopically identical we must also look for albumen, which in pyuria is generally present and in mucinuria may be absent. Mucus is more often seen in the urine of females.

5. BILE.

A yellow urine which retains its foam a long time after shaking, points to the presence of bile. The clothes are often stained a decided yellow by such urine.

GMELIN'S TEST.

A few drachms of fuming nitric acid are poured down the side of a test-tube so that it passes below the urine, just as in Heller's test for albumen. At the point of contact of the two fluids, if bile be present, a green ring is observed, and below it in order a blue, violet, and finally a yellow ring. The green ring is alone decisive. The presence of albumen does not disturb the test. The same play of colors is observed by putting a drop of the suspected urine on a clean porcelain back ground and putting a few drops of fuming nitric acid by it.

Chloroform as a test for bile in the urine is very satisfactory. Agitate a few drops of chloroform with

the suspected urine in a test-tube. If bile be present, the chloroform becomes turbid and acquires a yellowish hue, the depth of which is in proportion to the amount of bile present; the test fluid remains limpid.

CHAPTER IV.

SEDIMENT.

Normal urine is generally clear when just passed. Pathological urine may be passed cloudy or may become cloudy on standing.

A microscopical examination of this cloud or sediment forms the most important part of urinary analysis. For this a knowledge of the use of the microscope is absolutely indispensable; and not only this, but certain foreign substances, such as bits of animal fibres from wearing apparel, hair, oil, starch, granules from food, etc., etc., are so often found in the urine, that they should be familiar objects. Scratches and marks in the slide may be mistaken for sediment. It may not be out of place here to give a warning against unclean vessels and bottles in which urine is saved and brought for examination. It seems almost needless to state that cleanliness is very important in saving urine for examination. It has happened that spermatozoa have been found in female urine and vaginal epithelium in male urine. But more often from the female do we get foreign substances in the urine, and therefore it is well to request women to use a Davison syringe before the water is passed, or to pass the first part in one chamber and the rest in a clean chamber for examination.

If the sediment be abundant, a drop of it may at once be drawn up with a pipette, dropped on a slide and examined microscopically. If the sediment should be scanty, the urine should be well shaken and then poured into a conical glass to allow the sediment to fall to the bottom and be collected. All urine contains more or less sediment, which sinks rapidly to the bottom or floats for a long time, or even remains adherent to the sides of the vessel, according to its specific gravity. As an improvement on the conical glass, it has been suggested to allow such urine with scanty sediment to stand for twelve to twenty-four hours in a vessel with straight sides, such as a cylinder or test-tube with a foot. When the sediment has collected at the flat bottom, a pipette is introduced with the finger on the top and the lower stratum of urine and sediment drawn up and this pipette is allowed to stand in the cylinder, the whole being covered with paper or raw cotton, until this scanty sediment collects at the lower end of the pipette, when it is drawn out and dropped on a slide, carefully covered with a cover glass, and examined.

In a paper read before the Medical and Chirurgical State Faculty of Maryland in 1888, the writer collected a few hints on the microscopical examination of urinary sediment, and at the risk of repetition they are reproduced here:

Physicians now generally recognize the fact that an examination of the urine forms an important part

in making the diagnosis of any disease. In many cases negative results may satisfy, as excluding certain diseases. It is a matter of common occurrence that one physician not being successful in the treatment of a case, a consultant or another physician is tried, who, carefully examining the urine, a thing which the first adviser had failed to do, finds enough to throw considerable light on the malady and its treatment. In urinary analysis, an examination both chemical and microscopical should be made in all doubtful cases. The former is a matter not difficult for the majority of physicians, and there are few physicians who cannot make the ordinary tests for albumen, sugar, etc. The microscopical examination, however, is a matter not so simple. There are plenty of practitioners who cannot make a microscopical examination of the urinary sediment in a manner satisfactory to themselves. This part of the subject, though old and often discussed, may be repeated with advantage, even at the risk of uttering remarks well known and trite to many here.

First, as to the *technique*. The patient or attendant should be impressed every time with the importance of saving clean specimens of urine. The bottles and vessels in which the urine is collected and preserved should be scrupulously cleansed and dried. The urine obtained should be passed in the morning on rising and in the afternoon, so that two different samples may be examined. This is necessary, among

other reasons, because the urine may be free from albumen in the morning and loaded in the afternoon. These specimens should be examined as soon as possible after receiving them, and in case of keeping them, they should be preserved in a cool place, and some such substance as salicylic acid may be added which will not affect the examination.

Difficulties present themselves when the urine contains very much or very little sediment. When very little, it is the general custom to let it stand for twenty-four hours in a cool place in a conical glass, so that the sediment may drop to the bottom of the vessel. Casts when not abundant may remain suspended for a longer time in the urine, and owing to their lightness they may stick to the sloping sides of the glass and thus escape detection. Sometimes better results may be obtained by letting the urine stand in a cylindrical glass for twenty-four hours and then drawing up the bottom layer of fluid with a pipette and examining it. I have turned the bottle upside down for one day and then examined the sediment which had collected on the cork, but this is not usually satisfactory. For the microscope it is well to have a thick slide with a concavity ground in it.

When there is much sediment, it is not easy to separate the important from the unimportant matters. In this case it is better to let the urine stand in a cool place in a conical glass for six or twelve hours, and then pipette off the supernatant fluid and let that

stand in a second glass. Casts will be found in the second glass, and in the first, pus, blood, epithelium and inorganic matter.

There is a great difference between the urine of the male and female as regards sediment. Urine from the female generally contains large flakes of epithelium from the vagina, blood corpuscles, etc. This excess of sediment may be excluded by having the urine drawn off with a clean catheter, or by directing the patient to syringe out the vagina and genitals with warm water before urinating.

Red blood corpuscles are of no clinical significance unless present in large numbers. They may occasionally be mistaken for air or oil globules. Stray leucocytes are rarely absent, and are only to be considered when they are present in large numbers, as from a cystitis or rupture of some abscess in the genito-urinary-renal tract. Bladder epithelium, and, in the female, vaginal epithelium, is always present. Some of the bladder and vaginal cells so strongly resemble each other that they at times cannot be distinguished; and indeed vaginal epithelial cells have been described as being present in the male urine occasionally. Again, some cells from the bladder so much resemble epithelium from the ureter or renal pelvis that I always have trouble in distinguishing them. Renal epithelium, when it has not undergone fatty or other degeneration, is not difficult to recognize.

The principal object of the microscopical exami-

nation of the urine is to see if casts are present or absent. Although they are found in some of the acute diseases, and at times without sufficient explanation, still their continual presence cannot fail to be alarming. They should be looked for whether albumen be present or not. Albumen is often absent at the time of the microscopical examination, it having appeared at an earlier stage of the disease. Albuminuria without casts is said to be more common than it really is, and the majority of investigators agree in believing that casts are present though they can not always be found. This was deduced from autopsies. In an interesting case* of cyclic or physiological albuminuria, I was never able to find casts although I looked at intervals.

I generally draw off a little of the sediment with a pipette, and drop it on a hollow slide and examine it with a low power. The sediment may be then seen floating about. Most books warn against taking up too much fluid on the slide; I find this an advantage. I take up a large drop on an ordinary slide, and as the fluid runs along the slide, an opportunity is offered to review the sediment as it passes by, taking care, of course, that it does not get on the stage of the microscope. If casts are found, then another drop may be taken, and, before putting on a cover glass, a small bit

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* See author's article on "Cyclie Albuminuria," in the Medical News, July 30, 1887.

of broken cover glass or a hair is put by the preparation and then covered. This prevents the casts from being crushed. I generally prefer to examine first without a cover glass, because it is rarely necessary to use such a high power that the objective comes near the preparation. Some writers suggest that when there is much sediment, to roll the cover glass backward and forward with two fingers. I have done that several times and succeeded in making casts when there were none there. When a cover glass is used, as little liquid as possible should be taken up; and as this lessens the chance of finding them if few are present, it is not always advisable. Staining is generally superfluous, but if desirable, it is better to drop a little staining fluid in the urine, as staining under the cover glass causes the sediment to fly across the field at an alarming rate of speed and settle on the outside of the glass. This may be prevented by allowing the casts to dry on the slide and then staining; but this is apt to change their appearance, and is not advisable. The best way is to stain them before the cover glass is put on.

Numerous substances, such as camphor, carbolic acid, salicylic acid, borax, etc., etc., when added to urine containing casts, preserve these casts indefinitely. The urine may contain such a variety of sediment that careful study is very necessary in recognizing the various substances found. According as the urine is acid, or alkaline, concentrated or dilute, the

sediment varies, hence a reference to the following table will assist in the examination. Some of these substances are passed out with the urine from the bladder, while others are formed after the urine has been passed:

ORGANIZED MATTER.

1. Mucus and pus cells.
2. Blood corpuscles.
3. Epithelium.
4. Casts.
5. Spermatozoa:
6. Bacteria.
7. Papilloma cells.
8. Parasites.

UNORGANIZED MATTER.

Acid urine.	Alkaline urine.
AMORPHOROUS.	
1. Urate of sodium and potash.	1. Phosphate of calcium.
2. Fat.	2. Carbonate of calcium.
CRYSTALLINE.	
1. Uric acid.	1. Urate of ammonium.
2. Oxalate of lime.	2. Triple phosphates.
3. Cystin.	3. Phosphate of calcium.
4. Leucin and Tyrosin,	4. Phosphate of magnesium.

1. MUCUS AND PUS CELLS

Are found in all urine, and it is only when they are present in an especially large amount that they are considered pathological. In alkaline urine they swell up and take on a glassy appearance. When they contain fat drops they are probably from some abscess in the rectum, prostate, etc. In women they come from the vaginal secretion. Acetic acid renders the nucleus more distinct. Pus in the pelvis of the kidney appears mixed with the urine. From the bladder or prostate it is apt to be in plugs or threads—the urine is then strongly alkaline. When a gonorrhœa can be excluded, these masses of pus point almost certainly to a prostatic trouble.

2. BLOOD CORPUSCLES.

Almost all urine from women contains a few blood-corpuscles from the vagina, unless the urine be drawn off with a catheter. It is not always easy to say where the blood comes from, but if it be intimately mixed with the urine but in small quantities it is very likely from the kidneys, while if it appear in strings or clots either at the beginning or end of micturition, it is most probably from the bladder, prostate or urethra. When much blood is present it may thus be recognized. Such urine usually contains albumen from the disorganization of the blood-corpuscles. Red blood-corpuscles may be recognized with

a power of 300 diameters. They are bi-concave and from this shape the centers appear dark when the edges are clearly focused and the edges dark when the centers are focussed. In dilute urine the corpuscles swell up, and may even become bi-convex. In acid and concentrated urine they appear shrunken, and have crenated or jagged edges. A few leucocytes, or white blood-corpuscles, are present in all urine. In larger numbers they may be present as pus under such conditions as cystitis, gonorrhœa, vaginitis, or they may come from an abscess of the prostate or rectum. Occasionally, the blood appears in the urine in the form of cylinders or casts, which are undoubtedly from the kidneys. This will be referred to later.

3. EPITHELIUM.

The epithelium in the urine may come from the bladder, ureter, pelvis of the kidney, kidney, vagina or urethra. Epidermis cells often appear in the field of the microscope when the fingers have come in contact with the slide or preparation. It is probably impossible to distinguish cells of the ureters and renal pelvis, and even those of the bladder. The large flat vaginal epithelium may be recognized from its resemblance to the buccal epithelium. The bladder epithelium is easily recognized when the superficial and deep pear-shaped cells are seen floating together. Much more important is the recognition of the renal epithe-

lium. These cells are polygonal – generally hexagonal—are smaller than the other cells and contain a large nucleus. Their presence in the urine points to grave pathological changes in the kidney. They may appear singly, or adherent to casts.

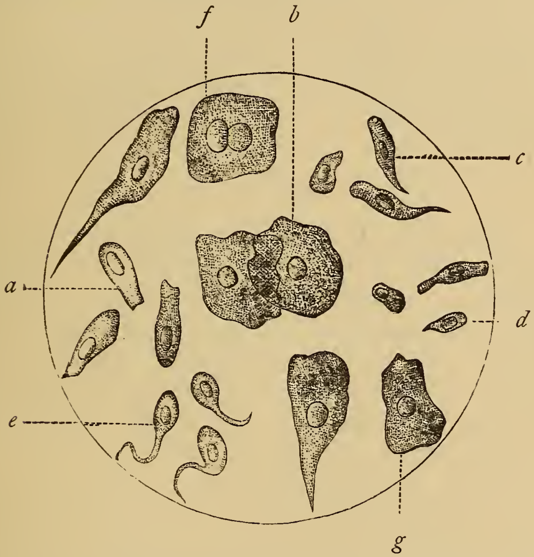

FIG. 8.—(*a*) Epithelium from Human Urethra; (*b*) Vagina; (*c*) Prostrate; (*d*) Cowper's Glands; (*e*) Littré's Glands; (*f*) Female Urethra; (*g*) Bladder.

The small round epithelial cells from the uriniferous tubules may be distinguished from pus cells by their size, and especially by their single nucleus clearly

visible, while the pus cell often has a multiple or lobulated nucleus, which is only visible on the addition of acetic acid. The flat epithelial or squamous cells of the bladder are not quite so large as those of the vagina, and do not usually appear in flakes or layers as those of the vagina do, still it is not always safe to attempt to distinguish between the two. When large multinuclear epithelium cells are seen in the urine, the presence of a cancerous (villous) growth may be suspected.

4. CASTS.

Tube-casts or epithelial cylinders form by far the most important pathological constituent of urinary sediment. They are so called because they are supposed to be moulds of the uriniferous tubules of the kidney. After being thus moulded they shrink and are carried out with the urine. They are supposed to be formed by a coagulable substance in the blood or by some morbid change of the renal epithelium. According to their appearance and composition they have received different names. Their presence points almost certainly to a diseased condition of the kidney. Until recently they were supposed to be accompanied by albuminuria, but, as is now known, either albumen or casts may be present without the other. The way to find them in the urine has already been mentioned. If the bottle of urine be placed upside down for twelve hours or longer, enough sediment

will be deposited on the cork to be examined. Repeated examinations of the urine are necessary before a decision is reached. Urine containing casts should be examined early after securing the specimen, as the bacteria and alkaline fermentation soon destroy the

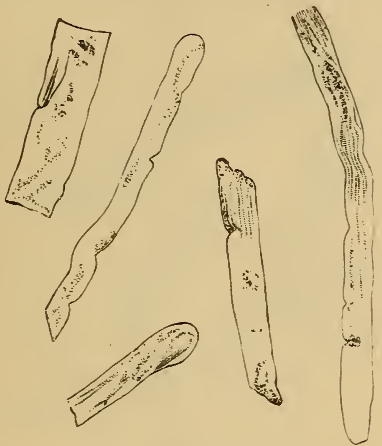

FIG. 9.—Hyalin Casts.

casts. A drop of carbolic acid is said to preserve the integrity of the casts; and also other substances, such as chloral, acetate of potassium, etc., have been suggested, but the risk of precipitating the albumen should always be avoided.

Dr. Charles H. Cockey, of Baltimore, uses a mixture of salicylic acid 2 parts, borax 1 part and glycerine 3 to 5 parts.

According to their appearance and composition, casts have received different names. If the mould of coagulated fibrin pass out with the urine without blood or cell, it is called a *hyaline cast* or *waxy cast.* According as epithelium, blood, fat drops, or granular matter (the two last from degenerated epithelium) are

FIG. 10.—Waxy Casts.

adherent to the moulds of fibrin, the casts are called respectively *epethelial*, *blood*, *fat*, or *granular casts.* These casts vary in diameter (from $\frac{1}{2500}$ to $\frac{1}{500}$ in.) according to the part of the tubule from which they come. Hyaline casts are naturally smaller than those to which epithelium, blood, etc., are attached. *Mucous casts* have also been described. Amorphous sediment and crystals may adhere to casts, and they also some-

times arrange themselves in a cylindrical form and deceive the inexperienced. Casts of the urates and of bacteria may be mentioned. In cleaning slides and cover-glasses, bits of linen threads are left on the glass and may be mistaken for the hyaline cast.

5. SPERMATOZOA

Are present in the urine occasionally, and are of interest from a medico-legal standpoint when found in the urine of women.

FIG. 11.—Blood Casts.

6. BACTERIA.

Freshly passed normal urine contains no bacteria; these are observed, however, in the alkaline fermentation. The two micro-organisms which have some diagnostic importance are the bacillus of tuberculosis and the gonococcus. In a suspected tubercu-

lous ulceration of the genito-urinary tract, an examination of the sediment or ulcerating matter will often decide the question. These bacilli are not so easy to find here as in the sputum, but the method is exactly the same.

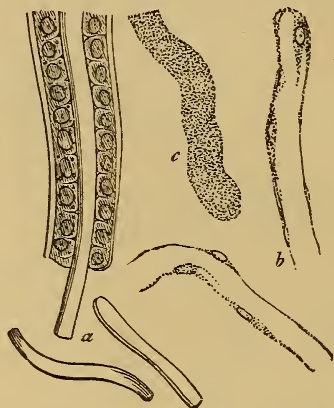

Fig. 12.—Hyaline and Granular Casts, illustrating the formation of the former at *a*.

This method is soon learned after a little practice by one already familiar with the use of the microscope. Others may not find it so easy, and there may be danger of drawing too hasty conclusions by those not versed in those matters.

A little of this sediment or ulcerating matter from the urine is spread out on a clean cover-glass with a sterilized platinum needle, or is taken up with

sterilized forceps and put in the center of a clean cover-glass upon which a second cover-glass is pressed, and then the two are drawn apart and allowed to dry. They are then passed through the alcohol or Bunsen flame to coagulate the albuminous substance and fix the layer on the glass. The principle of rendering the bacilli visible by staining them has been clearly enunciated by Koch and modified, *but not improved*, by

FIG. 13.—Epithelial Casts and Compound Granular Cells.

a host of followers. This principle of all is about the same, namely, to overstain the specimen and then decolorize, experience having shown that the bacilli retain their color better than the cells and other matter. The stains most commonly used are fuchsin or magenta, properly called hydrochlorate of rosanilin, and methyl-violet or gentian-violet. The coloring fluid which I find most convenient and durable is made up of—

Fuchsin (by weight)... ...	2	parts.
Absolute alcohol...........	10	"
Solution carbolic acid (5 p.c.)	100	"

This keeps better and longer than the ordinary anilin solutions, which should be prepared fresh for every examination. The cover-glass, with preparation side downwards, may be floated on the staining solu-

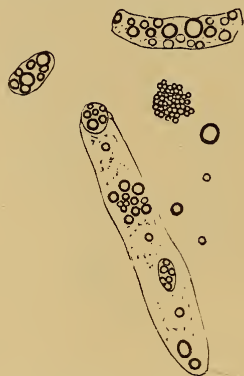

FIG. 14.—Oil Casts and Fatty Epithelium.

tion in a watch glass which is held on a wire gauze over the flame to hasten the coloring, or a few drops of the stain may be dropped on the color-glass, which is then cautiously held over the flame high above it until bubbles break on the surface; the glass is then dipped into diluted nitric acid (one to three or four), until slightly decolorized, then directly into water, to stop the decolorizing process, or some prefer to pass

it from the acid into alcohol. For immediate examination it is laid on a slide, the excess of liquid taken up by blotting paper and examined. An immersion lens is generally used to find these bacilli, but good dry lenses are made of sufficient strength and definition. Indeed, the bacilli may be recognized with 350 diameters, although it is not desirable to use less than 500.

The finding of the gonococus is easy, practicable and of decided importance in an ordinary case of gonorrhœa. The number present and their gradual disappearance in the discharge as the disease improves, are of decided assistance. Aside from this, the fact that some cases of salpingitis and other inflammatory conditions of the tubes or ovaries have been traced to an old gonorrhœa in the male, makes the search for the gonococcus very important in these obscure troubles.

The method of examination is very simple. A little of the pus is pressed between two cover-glasses, which are then drawn apart. Then the glasses are allowed to dry, and are quickly passed through the Bunsen flame to coagulate the albumen and fix the pus. Then a few drops of the ordinary methylene blue or violet* are allowed to cover the specimen for a few minutes and washed off. The specimen may at once be examined in water or glycerin, or it may be dried and mounted in balsam, which makes it more

*This is made by adding enough of a concentrated alcoholic solution of methylene blue or violet to distilled or clear water to give it a decided color.

distinct. The gonococci are seen in pairs or fours, apparently in the pus cells, while the contour of the pus cells is seen to be very indistinct, due to the Abbé illuminator.

The best way to confirm the discovery of a micro-organism is by cultivation and inoculation. This, of course, is not possible in every case of urethretis. Another way is by a process of staining which shall exclude every other micro-organism. Dr. Gabriel Roux, of Paris, says that if the preparation be first stained according to Gram* and then be examined, and then be decolorized with alcohol and examined again, the gonococci will be seen stained at the first examination, and will be unstained after decolorization with alcohol. Allen‡ and Wendt heartily confirm this. So far, I have not been doubtful in examining them myself, but as I have only looked for the gonococci in cases where gonorrhœa was undoubtedly present, my experience is of little value.

7. PAPILLOMA CELLS.

A villous cancer of the bladder may be suspected when bits of malignant growths in large multinuclear cells are found in the sediment.

---

*Gram's method consists in staining first with methylene blue or violet, fixing the color with a solution of iodine in iodide of potash, and then decolorizing with alcohol.

† Journal of Cutaneous and Genito-urinary Diseases, March, 1887.

FIG. 15.—URINARY SEDIMENT.—A, Uric acid; B, Acid ammonium urate; C, Sodium urate; D, Urea nitrate; E, (1) Leucin and (2) tyrosin; F, Cystin; G, Magnesium ammonium phosphate or triple phosphate; H, Calcium phosphate; I, Calcium oxalate; J, Blood corpuscles; K, Mucus and pus; L, Hæmin crystals; M, (1) Hyaline casts, (2) Granular casts; N, Epithelial casts and cells; O, (1) Waxy casts, (2) Casts with blood corpuscles, (3) Casts with fat globules.

8. PARASITES.

Parasites are not very common in this latitude, although occasional cases of filaria sanguinis hominis are reported. The distoma hæmatobium, and echinöococci, have been found.

UNORGANIZED SEDIMENT.

It is not easy to recognize all the varied kinds of unorganized sediment; but those that occur most commonly may be studied, and their recognition will be of decided importance. The amorphous matter has little significance under the microscope. The same salt occurs under different shapes—some rarely seen and some to be found in nearly every specimen examined.

URIC ACID.

Uric acid is present either as a slight reddish sediment at the bottom of the vessel, or, if abundant, it may be seen adherent to the sides of the vessel as brick-dust sediment, and when abundant is commonly called "sand" or "gravel." Those crystals have been compared in shape to a whetstone, barrel, envelope, spear, fan, comb, dumbbell, etc. This sediment may be dissolved on heating, or by adding caustic potash in solution.

URATES.

The sodium urates appear as fine amorphous granules, or as spherules with spicules or spines. The ammonium urates are in the shape of "thorn apples."

OXALATES.

The oxalates occur principally as the oxalate of lime crystals, which are in the shape of octohædra, or envelope and dumb-bell crystals. These crystals have no special significance, although they may point to mal-assimilation, when present.

PHOSPHATES.

The earthy phosphates occur principally as the triple phosphates in a large variety of shapes. They are found in alkaline urine in some affections of the bladder.

LEUCIN AND TYROSIN

are found in the urine in certain abnormal conditions of the liver. They are easily recognized in the sediment, or may be found on evaporating the urine.

CHAPTER V.

THE URINE IN DISEASE.

FEVER.

Quantity diminished, acid, of high specific gravity, dark color, abundant sediment of the urates. A microscopical examination may show, in addition, hyaline casts; albumen may be present.

Disturbance of circulation.

Much like the next condition, except that the albuminuria may be more lasting.

ACUTE NEPHRITIS.

In the beginning of this disease the quantity is diminished, acid, of high specific gravity, but not as high as in the last condition named. The urine is red from the presence of blood, and albumen is present. In the sediment are found red blood-corpuscles, leucocytes, renal and bladder epithelium, casts of blood.

CHRONIC NEPHRITIS.

Urine slightly diminished in quantity, acid, of normal specific gravity, much albumen. In the sediment are found epithelial cells, which have undergone fatty degeneration, also different kinds of casts, but

especially granular; aiso blood and epithelial casts and casts covered with fat crystals. The presence of these fat crystals and fatty cells points to chronic nephritis.

CONTRACTED KIDNEY.

Urine increased in amount, acid, specific gravity 1008 to 1012 aud lower with startling exceptions, color pale, little albumen and very little sediment, in which diligent search will show the presence of a few hyaline or slightly granular casts.

AMYLOID KIDNEY.

Urine much like the last condition.

DIABETES MELLITUS.

Quantity enormously increased, specific gravity 1030 and higher. Occasionally albumen.

DIABETES INSIPIDUS.

Quantity greatly increased, specific gravity very low, often 1002. No albumen. No danger except at rare intervals.

URÆMIA.

The amount of urine is much decreased, often to anuria, but in exceptional cases it may be normal in amount but with low specific gravity. Albumen and casts are usually present.

CYSTITIS.

The urine is acid unless it lies in the bladder and undergoes ammoniacal fermentation, when it is strongly alkaline. It is cloudy and contains a heavy sediment of fatty, swollen leucocytes and triple phosphate crystals. There is much pus, and layers of bladder epithelium and also blood present.

CALCULI.

They may be suspected when intermittent hæmaturia occurs from the bladder and the blood is not intimately mixed with the urine, but as a thick clot or sediment lies at the bottom of the vessel.

Tuberculosis and gonorrhœa may both be recognized by the staining methods already given. In digestion troubles, and principally in carcinoma of the stomach, the indican is increased in amount, but this is by no means pathognomonie, for the same is true in constipation. In certain cases of poisoning the substance may be detected by careful tests, but such tests are usually referred to the analytical chemist. The presence of certain drugs may be detected in the urine, but their presence has little significance except that they may affect the more common tests for sugar, albumen, etc. For instance, arsenic in the urine is said to act very much as sugar, reducing the copper in Fehlng's test.

CHAPTER VI.

4, REAGENTS AND APPARATUS.

In order to be able to examine urine with proper care, the apparatus and reagents should always be ready. To this end, the physician who makes any pretensions to examining urine regularly should have at one end of his office, preferably near running water, a table or shelf large enough to hold a series of bottles, a test-tube rack and all other necessities, and in this table several small drawers in which extra apparatus may be kept. Everything should be scrupulously clean and cleaned after each using, and the reagent bottles should always be kept filled, ready for use. It very often happens that a friend or physician will call with a specimen of urine to be examined for sugar or albumen at once. In such a case a bad impression is made, and loss of such work is entailed, if everything is not in proper order. Although the compact examining cases are very convenient at the bedside or in an emergency, the office-testing with table and apparatus is much to be preferred. The following are indispensable, other articles mentioned in this work may be added:

Concentrated hydrochloric or muriatic acid C. P.
" nitric " "
" sulphuric " "
" acetic " "
Glacial acetic acid.

Solution of caustic potash or caustic soda, 1 part to 2 of water.

Solution of sodium carbonate, 1 part of water to 3 parts sodium carbonate.

Liquor ammoniæ,

Solution of sulphate of copper (1 to 10 or 20).

" silver nitrate, 1 to 8 of water.

Subnitrate of bismuth.

Chloroform.

Alcohol.

Common salt.

Apparatus.—Test-tubes, conical glasses, litmus paper, urinometer and glass, spirit lamp or Bunsen burner, microscope and lenses, filter paper, glass vessels, rods, etc., etc.

CHAPTER VII.

ORDER OF ANALYSIS.

The urine is collected in a large vessel, and after standing for a few hours the upper part is poured off and the sediment put aside for microscopical examination. After noting the amount in twenty-four hours, color, consistency, transparency, smell, reaction, specific gravity and quantity of sediment, a little of the clear urine is poured into a test-tube and heated to the boiling point. If a cloudiness arise, it is due either to albumen or to the earthy phosphates. Add one or two drops of acetic acid, and if the cloudiness disappear it was due to the phosphates; if it remain, it is albumen. Then add one-half as much of a caustic potash solution as there is urine in the test-tube, and if albumen be present it will be dissolved, while the earthy phosphates fall as a thick white cloud to the bottom of the tube. If the earthy phosphates become brown on heating, sugar is most probably present; if red, blood-coloring matter. In the latter case albumen is probably also present, and the presence of the hæmin crystals and the red blood-corpuscles may be demonstrated by the microscope. The sediment should then be examined microscopically. In making many examinations, it is generally more convenient to have a blank form in which the results

may be systematically recorded for oneself or for another physician.

The following will be found convenient:

EXAMINATION OF URINE.

For .... at the request of Dr. ....

PHYSICAL PROPERTIES,

Quantity in 24 hours.........	Specific gravity...... .....
Color	Quantity and character of the sediment.............
Reaction....	
Odor	

ABNORMAL CONSTITUENTS IN SOLUTION.

Albumen	Bile ....
Sugar	

SEDIMENT.

Casts	Oil ....
Pus.........................	Crystals ....
Blood	Date ....

Name ....

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